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INFECTION BY THE GAS BACILLUS IN COAL-MINES.*

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The discovery by Professor Welch in 1891 of *B. welchii*, and the observed relationship of this organism to the production of gas in the tissues was the first definite evidence that the inflation of tissues before and after death was commonly due to bacterial invasion. The presence of free gas in various parts of the body has been commented upon in the literature by many of the older writers, and for some time it strengthened the belief that air was an important constituent of the circulation. Simple putrefaction was suggested by others as the cause of the accumulation of this gas. On the other hand, prior to Welch's discovery, we have the observations of Pasteur, Koch, and their pupils, which indicate that a type of organism was found and known to them which in all probability belonged to the *B. welchii* group.

Welch and Nuttall published their first report in 1892. Then there followed a series of observations from the laboratories at Johns Hopkins Hospital indicating the wide distribution of this organism in nature and disease. Almost simultaneously there appeared in Germany and France similar observations by Fraenkel, Ernst, Goebel, Dobbin, and others. The importance of this type of infection was emphasized by each, and the danger of its presence in deep wounds, particularly when associated with other pyogenic bacteria, was appreciated by the surgeon. With, however, the improved technic in bacteriology, along with keen interest for the isolation of new anaerobic forms, we find that several investigators determined the presence of organisms, simulating in many respects *B. welchii*, but on account of finding them in new locations and of slight, possibly transient variations, applied a new nomenclature. Thus Fraenkel, finding a large anaerobic bacillus in gaseous phlegmons gave it the name *B. phlegmones emphysematosae;* Veillon and Zuber isolated bacilli from cases of otitis media, pulmonary gangrene, mastoiditis, appendicitis, and pelvic abscess which they

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called *B. perfringens;* Lindenthal, in 1897, isolated an organism from the emphysematous tissues about the vagina, to which he gave the name *B. emphysematis vaginae.* Likewise to an organism isolated from milk and water and having characters of *B. welchii,* Schattenfroh and Grassberger gave the name *Granulobacillus saccharobutyricus immobilis liquefaciens.*

No general systematic study has been undertaken to determine which of these organisms are identical with or belong to the group of organisms of which *B. welchii* is the important representative. It is probable that the slight variations which have been observed in these somewhat similar organisms are real, but it is plain that, with the meager information obtainable for many of them, no very definite statement can be made for their isolated identity. To this uncertain class might be added *B. vaginae* (Kruse), *B. cadaveris* (Sternberg), and *B. cadaveris butyricus* (Buday). It is also evident that many of the cases of human infection which have been described in America as malignant edema are instances of infection by the *B. welchii.* Clinically, some cases presenting features of malignant edema with progressive gangrene, in which very little gas can be demonstrated in the tissues, show on bacteriological examination the presence of the "gas bacillus" along with other organisms.

Some confusion has also arisen between *B. welchii* and *B. enteriditis sporogenes* (Klein). The latter organism has been isolated by Klein from a great number of sources (sewage, manure, feces, street dust, milk, etc.). This organism has certain characters which distinguish it from the organism of Welch, particularly to be observed in the presence of flagella and motility. Klein reports the ease with which spores are produced in tissues; but this appears to vary with certain strains, and in cultures is equally difficult to obtain as with *B. welchii.* Again it is pointed out that *B. enteriditis sporogenes* is highly virulent, but this too is not constant, as the cultures of the organism may rapidly lose their virulence. There is, however, a striking resemblance between the organisms of Klein and that of Welch in the production of gas in the animal tissues. By using the same procedure as Welch of inoculating the organism into the veins and then killing the animal and incubating, Klein has found that *B. enteriditis sporogenes* produces much gaseous emphysema throughout the body. Another feature in which these organisms resemble each other is the sparse growth of thin translucent colonies on surface agar.

A most comprehensive study of the "Morbid Conditions Caused by *Bacillus aerogenes capsulatus*" is given by Professor Welch in his Shattuck Lecture of 1900. It is pointed out by Welch that the duplication of nomenclature has led to much confusion in the discussion of the bacteriology of emphysematous gangrene. This we have met with in our study, but it has also appeared to us that *B. welchii* constitutes a group of organisms, each of which may produce gas in tissues, and have some slight variation in morphological or cultural features.

Our attention was attracted to this infection by the unusual frequency of emphysematous gangrene occurring in the surgical wards of the hospitals in Pittsburgh. For the clinical data we are indebted to Drs. R. W. Stewart, J. J. Buchanan, G. L. Hays, A. Stewart, and J. P. Griffith, surgeons at the Mercy Hospital.

The reports of the cases comprising this study have been taken from the records of the Mercy Hospital at Pittsburgh. There are 36 cases in all, in which both the clinical and bacteriological examinations demonstrated the presence of *B. welchii* or one of the members of this group. A number of other cases in which a satisfactory analysis of the bacterial infection was not forthcoming were not included, although we felt that some of them at least were infections by the gas bacillus. These latter cases gave clinical evidence of gas in the tissues at the point of injury, some also showing indurative edema with gangrene, but a bacteriological examination had been omitted. These cases must remain in the undetermined class, but we feel with Welch that the production of gaseous gangrene in life is in the majority of cases due to the infection of *B. welchii* or one of the members of this group, and that gas formation in tissues by *B. coli* remains unproved, save possibly in a few reported cases of diabetes. Concerning infections by the bacillus of malignant edema in man, we have had no experience, and believe that authentic cases of this condition in America are extremely rare.

As the hospital from which our records are taken does not admit maternity cases we have no instance in this series of uterine infections by *B. welchii.*

TABLE 1.

Number	Age	Sex	Occupation	Nature of Accident	Nature of Wound	Result
1	27	Male	Bridge-builder	Fall from bridge	Comp'd fracture of arm	Recovery
2	31	Male	Telephone lineman	Fall from pole	Comp'd fracture of arm	Recovery
3	20	Male	Coal-miner	Run over by car in mine	Comp'd fracture of ankle	Recovery
4	14	Male	Coal-miner	Run over by car in mine	Comp'd fracture of both thighs	Recovery
5	28	Male	Coal-miner	Fall of slate in mine	Comp'd fracture of fibula and tibia	Death
6	24	Male	Laborer	Accident at steel works	Comp'd fracture of leg	Recovery
7	42	Male	Coal-miner	Fall of slate in mine	Crush of foot (open wound)	Death
8	16	Male	Mill worker	Accident at steel works	Crush of foot (open wound)	Recovery
9	72	Male	Coal-miner	Crush by cars in mine	Laceration of leg (open)	Death
10	31	Male	Coal-miner	Crush in mine	Comp'd fracture of leg	Death
11	19	Male	Brakeman	Crush by train	Comp'd fracture of hand	Death
12	54	Male	Coal-miner	Crush in mine	Comp'd fracture of leg	Death
13	29	Male	Coal-miner	Crush by cars in mine	Comp'd fracture of leg	Recovery
14	25	Male	Coal-miner	Crush by car in mine	Comp'd fracture of femur	Death
15	25	Male	Electrician	Fall from scaffold at a mill	Comp'd fracture of radius	Recovery
16	23	Male	Coal-miner	Fall of slate in mine	Comp'd fracture of fibula	Recovery
17	45	Male	Coal-miner	Fall of slate in mine	Laceration of foot	Recovery
18	31	Male	Coal-miner	Crush by car in mine	Left thigh almost severed	Recovery
19	21	Female	Housewife	Fall from porch	Cut forearm in glass on ground	Recovery
20	19	Male	Laborer	Explosion of powder	Fracture of leg with laceration	Recovery
21	23	Male	Mine driver	Crush by car in mine	Comp'd fracture of both legs	Recovery
22	36	Male	Mill worker	Crush in mill	Comp'd fracture of both legs	Recovery
23	17	Male	Coal-miner	Crush by car in mine	Comp'd fracture of leg	Death
24	28	Male	Laborer	Fall into ditch 15 ft.	Comp'd fracture of femur	Death
25	9	Male	School boy	Fall from ladder	Comp'd fracture of forearm	Recovery
26	23	Male	Machinist	Fall from box-car	Comp'd fracture of humerus	Death
27	39	Male	Coal-miner	Injured by mine truck	Comp'd fracture of tibia	Recovery
28	32	Male	Coal-miner	Crush in mine	Thigh lacerated	Death
29	9	Male	School boy	Fall from tree	Comp'd fracture of forearm	Death
30	40	Male	Laborer	Train accident	Crush of left arm	Recovery
31	38	Male	Coal-miner	Fall of slate in mine	Comp'd fracture of ankle	Recovery
32	30	Male	Laborer	Run over by street car	Crush of left leg	Death
33	15	Male	School boy	Run over by train	Crush of legs	Recovery
34	61	Male	Coal-miner	Crush by car in mine	Laceration of thigh	Death
35	24	Male	Coal-miner	Crush by car in mine	Crush of heel	Recovery
36	24	Male	Coal-miner	Fall under car in mine	Comp'd fracture of both legs	Death

Gas present in tissues in all cases.

In summarizing the above 36 cases we find that there were 35 males and one female. The youngest individual was nine years and the oldest 72 years. The average age was 31 years. Every case in the series had a severe external wound. There were 23 cases with compound fractures. Of these, 16 were of the lower and seven of the upper extremity. The remaining 13 cases consisted of severe lacerated flesh wounds in which no bones were broken but in which extensive areas were laid bare to infection of all kinds. The very nature of these accidents where great mechanical injury was received, led, in nearly all cases, to the fall of the individual to the ground. It is this feature, the pollution of the wound by the infected soil, in many instances the dirt being ground into the tissues, which makes these lesions very susceptible to this form of infection.

More interesting, however, is the evidence of occupation susceptibility. Of the 36 cases which we here report, there were 20 coal-miners who received their wounds while at work in the mines. The accidents leading to the extensive lacerations were of two kinds: (1) the falling of the slate from the roof of the mine upon the workman; or (2) crush-accidents between or under the mine cars. In either case the individual received lacerations with large open wounds which readily became infected by the soil of the mine. Temporary first-aid treatment was received in the mine. The severe wounds were later given hospital treatment. Gas in the tissues about the wound was observed to occur as early as 12 hours, and as late as four days, after the accident. Of the entire 36 cases reported, 40 per cent proved fatal, while of those receiving their injury in the coal mines, the mortality was 50 per cent.

Of the remaining 16 cases not working in the mines there were:

Laborers	5	Electrician	1
School boys	3	Brakeman	1
Mill workers	3	Telephone lineman	1
Bridge-builder	1	Housewife	1

In all instances but one, the injuries were received while the individual was out-of-doors, and in the majority of these 16 cases the wounds were obtained on the street or some driveway or in a garden. Two of the school boys were injured in a fall in a garden, from a ladder and a tree respectively. The injury, with gas-bacillus infection in a woman, was received in a fall from a porch on to the garden soil. Three individuals were injured in railroad accidents, in which the lacerated wounds were soiled by the earth along the railroad tracks. One case developed tetanus after the appearance of gaseous emphysema.

It is significant in all of these cases that the wounds were infected by earth, dirt, or materials which themselves were open to fecal pollution from either man or animals. It is obvious that the highways are repeatedly reinfected by various pathogenic organisms, and although sunlight and rain greatly assist in removing from the surface the presence of living bacteria, a great variation exists in the extent of this disinfection. The presence of moisture, shade, and porous organic substances assists greatly in preventing the destruction of many bacteria. Great variation, too, exists among the individual organisms in their resistance to external destructive influences, so that soil and dust, although subject to climatic changes, commonly contain an abundance of spore-bearing bacteria and such other organisms which are not so readily affected by variable temperature and light.

It has been demonstrated by many observers that *B. welchii* and its closely related forms are almost constant inhabitants of the intestines of both man and animals. Welch and Flexner, Clopton and Howard have isolated this bacillus from the intestines of man, while Welch has also demonstrated its presence in the bowel of rabbits, dogs, and swine, and Houston obtained it in cow dung. Walker isolated the organism from the dust of hospital wards; Harris has found it in the contents of cesspools, and Fraenkel has obtained it in a splinter of wood which had led to an emphysematous infection of a wound. We have isolated a gas bacillus with characters of *B. welchii* from rich garden earth, and we have also obtained it from the tissues of a cadaver undergoing putrefaction in whom no external wound of entry existed. It is evident, therefore, that this bacillus is widely disseminated in nature and that the contamination of the soil will continue to exist in such localities where repeated fecal pollution takes place.

In being confronted by the evidence of the high incidence of infection by the gas bacillus in coal-mines, it was obvious that the bacterial contamination had been carried into the mine subsequent to its opening and development. The conditions that are present in the majority of these mines are favorable for the development and protection of bacteria which may find their way into the mine. The protection from light, drying, and excessive ranges of temperature permits the bacteria to persist for long periods of time in the damp soil.

In the examination of a coal-mine in which mules were used in the most distant underground workings, we had no difficulty in isolating *B. welchii* from the soft earth in several of the paths along which they traveled. It is probable that even when these animals are taken from a certain route the ground infection from the feces persists for a considerable period. Moreover, a certain amount of distant dissemination of the organisms takes place through the trickling of water and the carriage of the organism on the shoes of the laborers along many of the paths. It was found, too, that the men polluted the abandoned rooms or a portion of a room from which coal was being taken, by defecating in them. This practice leads to the distribution of large numbers of bacteria of all kinds to a region where there is a natural absence of organisms. Moreover, the injuries received by the miners by falling slate or coal were in the majority of instances received in the working rooms where this human pollution is found; while on the other hand, the injuries obtained about the truck cars were in the galleries where the mules are, or formerly were, frequently passing to and fro.

It seems quite obvious, therefore, that infection by *B. welchii* and other bacteria in coal-mines is a direct outcome of fecal pollution of the ground by man and animals.

It has been repeatedly noted at autopsy that much hemolysis occurred in individuals infected by the gas bacillus. The blood within the vessels is laked, and the vessels immediately after death, and probably during life, show a cherry-red staining of the tissues. Not only do the blood vessels show this hemoglobin imbibition, but it is also to be observed in the parenchymatous organs. Our observations on the hemolytic effect of our cultures on blood agar is in agreement with these vital findings.

More definite evidence of the effect of the gas bacillus upon the red blood cells is brought forward by the clinical blood examinations carried out under the direction of Dr. G. L. Hays. We are much indebted to Dr. Hays for the privilege of using some of his records of blood counts. It is quite obvious that, on account of the nature of this infection, there is quite a variation in the constitutional reaction in different individuals.

In some cases the infection is very localized, in others the emphysematous gangrene spreads progressively, while in the very severe cases the organisms soon become invaders of the blood stream. In like manner, the effect upon the blood-cells is directly dependent upon the absorption of the hemolysins from the infected site, the blood infection naturally being the most severe.

November 1, 1910......	Coal miner, adult, 39 years. Compound fracture of tibia by a coal car in the mine. Arrived at hospital seven and one-half hours after injury was received.		
November 3, 1910......	*B. welchii* was isolated		
	Red cells	3,450,000	Hemoglobin
	Leukocytes	17,800	
November 6, 1910......	Red cells	3,240,000	Hemoglobin 78 per cent
	Leukocytes	19,420	
November 7, 1910......	Red cells	3,190,000	Hemoglobin 78 per cent
	Leukocytes	20,400	
November 8, 1910......	Red cells	2,880,000	Hemoglobin 76 per cent
	Leukocytes	20,000	
November 9, 1910......	Red cells	2,170,000	Hemoglobin 73 per cent
	Leukocytes	15,120	
November 13, 1910......	Red cells	2,220,000	Hemoglobin 75 per cent
	Leukocytes	13,250	
November 15, 1910......	Red cells	2,280,000	Hemoglobin 75 per cent
	Leukocytes	11,200	
November 17, 1910......	Red cells	2,940,000	Hemoglobin 77 per cent
	Leukocytes	10,920	
November 19, 1910......	Red cells	3,130,000	Hemoglobin 77 per cent
	Leukocytes	9,800	
November 22, 1910......	Red cells	3,440,000	Hemoglobin 78 per cent
	Leukocytes	9,400	
November 26, 1910......	Red cells	3,840,000	Hemoglobin 81 per cent
	Leukocytes	8,000	
December 11, 1910......	Red cells	4,680,000	Hemoglobin 84 per cent
	Leukocytes	7,800	

Recovery

In two other cases blood counts were similarly carried out. In the one, the red cells fell to 2,590,000, in the other to 4,000,000. It was observed in each case that the greatest anemia was not immediately after the accident when a certain amount of hemorrhage occurred, but the fall in the red cells was progressive from day to day until the infection was overcome and convalescence was taking place. It is quite probable that this secondary anemia is an important factor in determining the issue of this infection. It is apparent, too, that much of the hemoglobin continues to circulate with the blood, the liver and the spleen being unable to remove the quantity liberated.

BACTERIOLOGICAL.

The isolation and determination of *B. welchii* from infected wounds is attended by considerable difficulties. The first and majority of the cases here reported were determined by the simple methods described by various authors, and which can be only taken to indicate the presence of one of the members of the gas-bacillus group. In the last nine cases attempts were made to isolate the organisms in pure culture and to determine the cultural characteristics of each. It has been our experience that these infected wounds always harbored mixed cultures. In one instance a pure culture of *B. welchii* was obtained from the heart blood at autopsy. The wound (compound fracture of the leg) contained several types of bacteria, including *B. welchii*, but the gas bacillus was the only one which invaded the blood. As this autopsy was performed one hour after death it is probable that the organism began its invasion of the systemic circulation during life. Streptococci are probably most frequently associated with the infection by the gas bacillus, and it is even suggested by some that *B. welchii* requires this or some other organism to produce conditions favorable for its growth in the tissues. Welch, however, has shown that aseptic lesions, presenting areas of less resistance, readily become the nidus for the gas bacillus, and that, therefore, a primary infection of a different nature was not essential. The nature of the bacteria present in a lacerated wound is obviously dependent upon the bacteria present in the contaminating materials. Hence, the types of the organisms which may be associated with *B. welchii* are very numerous.

In the usual routine the determination of the infection in a case of gaseous emphysema has depended upon both a clinical and preliminary bacteriological examination. The presence of a lacerated wound, not in the region of the lungs or air passages, showing a progressive infiltration with gas, along with more or less edema and gangrene, from which the smears show large gram-positive bacilli with rounded ends and occasionally showing spores and capsules has, along with the cultural production of a "stormy fermentation" in milk, been indicative of a gas bacillus infection. To this, the presumptive test of gas production in the tissues of an animal which had been inoculated, killed, and incubated, has been of further confirmatory value.

It is evident from the reports of Klein that other organisms belonging to this group may produce gas in the tissues, so that the presumptive test by the inoculation of material into the tissues of an animal with subsequent gas production does not prove the identity of the organism but rather of a group of organisms.

It has been observed by others that some confusion has arisen on account of the varying staining reactions exhibited by this organism. We have noted that *B. welchii* stains readily with the simple stains, and that the majority of the organisms obtained from the infected tissues are gram positive. In such smears a few bacilli lose the gram stain. The organisms, however, taken from older cultures have a most irregular action to this stain. In some cases the majority may be gram negative while others contain gram-positive masses or show a polar staining. The older cultures tend to become gram negative, but fresh cultures from these may again give rise to gram-positive organisms. It was observed, however, that certain cultures had a greater tendency to produce irregular staining and gram-negative forms than others. In a like manner there is some difficulty in obtaining uniform results with the capsule stain. We have found that capsules are best demonstrated from the fresh tissue and from the growths on Loeffler's blood serum.

B. welchii is non-motile. Spores are not readily formed. We have observed them both in fresh smears from the tissues and also in cultures on Loeffler's blood serum, but they are seldom present in abundance. In one strain isolated we have obtained spores in cultures with comparative ease.

In our later cases we have isolated *B. welchii* in pure culture and determined the cultural characters. These have corresponded to the characters described by Welch, and to them we have added a number of other features which may be of assistance.

For the production of anaerobism we have used the pyrogallic-acid method, while for the separation of mixed cultures we have used the deep-agar (dextrose) shake method. In almost all cases it was necessary to repeat the process for separation several times before an individual pure colony could be picked. This was then planted in media for the differentiation. It was observed that the complete fermentation of the various media occurred very rapidly and that no further change took place in the media after 48 hours. The inoculated gelatin was incubated with the other tubes, and after removal from the incubator it was chilled in the refrigerator. By this means growth was always obtained and the complete liquefaction of the gelatin occurred in 24 to 36 hours; when, however, the gelatin cultures were permitted to develop at lower temperatures, the growth and liquefaction were very much slower. We believe that if the method of incubation is used for gelatin cultures, uniform results of liquefaction of this medium will be obtained for this organism. The following characters and reactions on media were obtained when *B. welchii* was grown anaerobically:

Broth	Poor growth at bottom of tube. Upper liquid clear
Agar slant	Fine discrete translucent gray colonies of less than pinhead size
Blood agar	Fine discrete gray colonies with hemolysis
Gelatin	Complete liquefaction
Dunhams	No indol. Growth poor
Dextrose broth	Acid and gas
Lactose broth	Acid and gas
Saccharose broth	Acid and gas
Mannite broth	No acid and no gas
Potato	Invisible—sometimes a moist appearance along line of inoculation
Milk	Acid and coagulation with gas. "Stormy fermentation." Strong odor of butyric acid
Loeffler's blood serum	Moist gray colonies, sunken below the surface. Liquefaction of the medium continues

The fermentation of various sugars can also be observed in stab or shake agar to which the various sugars have been added. In such agar tubes the fermentation was at times so great as to force the plug and some of the agar out of the tube. The surface colonies were found to rapidly lose their vitality so that further transfers from them were unsuccessful. The inoculation of the organism into the blood stream of the small animals gave rise, after death, to a great production of gas in the tissues of the entire body. From these tissues the bacillus was again isolated.

In an attempt to do away with animals in these experiments, we introduced the bacillus into fresh liver tissue obtained from the butcher. Both beef and calf livers were used, and although a production of gas was obtained in them, we found an equal amount produced in the uninoculated controls. From these control portions of the liver, a gram-positive bacillus was obtained closely resembling *B. welchii*, but we have not up to the present been able to isolate it in pure culture. These microorganisms with the production of gas in beef and calf livers were obtained in six different controls and precluded the use of these tissues for these experiments. We similarly encountered difficulties in the use of guinea-pig liver. In the latter instance, some of the liver of a guinea-pig was removed sterilely and placed in the Smith fermentation tubes to facilitate the anaerobic condition. We found, however, that this too was impractical, in that there was a gas production in the uninoculated liver, with the growth of a gas-bacillus-like organism. These results are very similar to those of Wolbach and Saiki who found that the healthy livers of dogs contained bacilli growing only anaerobically.

From one of the human cases there was isolated an organism with the general characters of *B. welchii* and which by the simple methods would have been classed as this bacillus. It was found, however, to be quite distinct in its cultural characters from the one above described.

The organism was obtained from the lacerated wound of a compound fracture which ended fatally, and by means of anaerobic shake cultures it was separated in pure culture from streptococci and from gram-negative aerobes. The bacilli were large organisms with blunt ends and rounded corners. They stained readily with ordinary stains and were gram positive. Spores were observed in the original material and were also seen later in old serum cultures. The organism usually appeared singly or in pairs, seldom in chains. Cultures were only obtained by anaerobic methods. Motility was observed in fresh cultures. The cultural characters were as follows:

Broth	Very scanty growth at bottom
Agar	Thin transparent grayish growth along streak
Gelatin	No liquefaction
Potato	Much gas in fluid below medium; surface of medium moist; colony invisible
Dunhams	No indol
Litmus milk	Acid with firm clotting, gas and clear whey, odor of butyric acid. No softening of clot
Dextrose broth	Acid and gas
Lactose broth	Acid and gas
Saccharose broth	Acid and gas
Mannite broth	No acid, no gas
Dulcite	No acid, no gas
Loeffler's blood serum	Fine gray colonies with gray flocculi in the water condensation. No evidence of liquefaction

Animal test.—The inoculation of the organisms into the circulation led to a great distension of the tissue and organs with gas (18 hours after the death of the animal).

Subcutaneous inoculation of the organism into the healthy tissues of a rat was without effect.

We have, then, to deal with an organism belonging to the gas-bacillus group, but differing from the bacillus of Welch in the presence of motility, the non-liquefaction of gelatin and blood serum, and the readiness with which it produced spores on serum media. Spores were also observed in the colonies of deep-agar shake cultures. The surface colonies on agar were more diffuse and not so discrete as those of the true *B. welchii*. It simulated closely *B. butyricus* of Botkin as described by Klein.

SUMMARY.

There appears, from our findings, to be an unusual frequency of infection by the gas bacillus among those receiving lacerated injuries in the coal-mines. This infection gives all the clinical manifestations of gaseous phlegmon while the bacteriological analysis indicates the presence of a member of the *B. welchii* group of organisms. These organisms, save one, which we have been able to isolate in pure culture and cultivate on differential media, conform with the characters of the *B. welchii* which have been described by Welch. One strain of organism was isolated which had many of the characters of *B. butyricus* of Botkin.

In the light of Klein's work on *B. enteriditis sporogenes* and *B. butyricus* of Botkin and with our isolation of an organism belonging to the gas-bacillus group having, however, definite characters separating it from *B. welchii*, it is evident that other anaerobic bacteria, simulating in many respects the gas bacillus of Welch, may produce an emphysematous gangrene in man. In all probability, therefore, the infection by the so-called gas bacillus indicates a disease produced by a group of organisms with many features in common rather than by a single organism.

The clinical observations of the rapid destruction of the red blood cells during life in these infections is of great interest, and is probably associated with the rapidly fatal course in many cases. The hemolytic effect may also be observed in cultures.

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